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Impact of Land Degradation on Future World Food Production

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ABSTRACT

Land degradation will likely curb agricultural production increases in the developing countries of Africa, Asia, and Central and South America. Growing populations and weak economies in many countries will seriously hamper efforts to bring new land under cultivation. Forty percent of the world's available land is being farmed, representing the best soils, but cultivating the remaining sparsely populated and often marginal 60 percent of land will require expensive farming techniques and new technology. Improved land management will likely spur per capita food increases in the developed countries.

Keywords: Land degradation, desertification, productivity, soil.

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SUMMARY

Agricultural land productivity has not reached its potential in much of the world because past land degradation is restraining current production. Land degradation, or desertification, is, at its worst, the deterioration of productive soil into barren land. Degradation is caused by erosion from water, wind, waterlogging, salinization, compaction, surface crusting, and destruction of vegetative cover.

Only 40 percent of the world's available land is being farmed. However, growing populations and often weak economies will seriously hamper expensive and complex efforts to bring new land under cultivation. Expansion of cultivated areas frequently leads to degradation of the new land.

This report assesses how anticipated land degradation will affect land productivity and future world food supplies. Per capita food production will likely increase in developed countries, primarily on the continents of Australia, Europe, and North America, spurred by improved land management techniques, and, in some cases, the reversal of moderate desertification. These continents have suffered only slight to moderate desertification.

The large majority of the developing countries (primarily in Africa, Asia, and Central and South America) will have difficulty increasing food production. Although desertification could be halted, and even reversed, in these developing nations, the deceptively slow degradation process is frequently overlooked, and the cost of reversing current desertification is steep. This, combined with the additional expense of expanding cultivation to new lands, will make it difficult for these developing nations to increase food production to meet rising populations.

Following are land degradation problems and prospects for agricultural production by continent:

- Africa--Severe degradation of rangeland and cropland is most extensive north of the equator, and especially on the north and south sides of the Sahara. Food production will likely increase slowly on the continent through improved management practices. South Africa and Botswana will probably increase crop yields faster than other African countries. Lesotho, Ethiopia, and the semiarid and subhumid regions between the Gulf of Guinea and the Sahara suffer from water erosion and will likely face declining per capita food production.

- Asia--Longstanding degradation problems in Southwest Asia and relatively recent deterioration in Southeast Asia

will hinder overall agricultural output in parts of Asia. However, yields should increase slowly until the year 2000 based on farming improvements in the Philippines, North and South Korea, Taiwan, Japan, the Soviet Union, Israel, and, perhaps, Turkey. Nepal and Indonesia will probably suffer severely from water-eroded soils.

° Australia and New Zealand--Overgrazing and erosion have desertified a large segment of Australian rangeland. Desertification is minor in New Zealand. Productivity of cultivated lands is expected to increase steadily. Meat production will grow somewhat in New Zealand and stabilize in Australia's arid rangelands but increase in subhumid Queensland and in New South Wales. The highest potential yields should center in eastern and southeastern Australia and on the North Island of New Zealand.

° Europe--Desertification has been reversed in some countries, but severely eroded soils persist in parts of Spain, Italy, and Greece. Improved small-farm technology should bolster food production. The greatest potential lies in the broad valleys and flood plains along the Mediterranean coast from France to Greece.

° North and Central America--Desertification will not likely affect crop production in Canada and the humid regions of the United States and Mexico. It will blunt crop production increases in the subhumid and semiarid regions of the United States and Mexico, as well as in the Central American mountains. Virtually all of the best arable land in much of North and Central America is under cultivation.

° South America--Land degradation is most severe on the cultivated lands of the Andes Mountains. Water and wind erosion have damaged some Argentine farmland, and salinization and waterlogging have hampered farmers from Peru's coastal desert into Brazil. This continent has the highest potential for increased productivity. However, most of the cultivable land is in the sparsely populated Amazon Basin, an area unsuitable for large-scale mechanized farming and subject to land degradation because of fragile soils. Projected per capita gains are expected to be slow.

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INTRODUCTION

Land degradation, or desertification, threatens to blunt agricultural efforts to keep pace with the global population surge. The degradation is caused by erosion from water, wind, waterlogging, salinization, compaction, surface crusting, and destruction of vegetative cover.

This study evaluates the quality and amount of global agricultural land resources and assesses the impact of land degradation on food production. Specifically, the objectives include:

- Estimating rates of land degradation.
- Estimating the current status of land productivity.
- Assessing how anticipated land degradation will affect land productivity and future world food supplies.

The importance and urgency of investigating the relationship between soil degradation and future world food supplies focuses on the pressures of an ever-increasing population upon land resources. Such pressures are related to the effects of land, air, and water pollution which affect world productive potential (5).1/ The United Nations' 1979 projections of world population trends indicate that by the year 2000 there will be between 5.8 and 6.5 billion people, a 29- to 44-percent increase over the estimated 1980 population of 4.5 billion people. As the world's rapidly increasing population requires stepped-up food production, the productivity of much of the land that must supply that food is steadily deteriorating.

In 1970, about 1.4 billion hectares (3.6 billion acres), or 40 percent of the world's arable land, were cropped out of the total potentially arable land of 2.5 to 3.2 billion hectares (7, 9). Much of potentially arable land not presently farmed will require large investments in machinery, fertilizers, pesticides, and water control (2). About 800 million hectares

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1/ Underlined numbers in parentheses cite sources in the References section.

lie in the humid tropics of Latin America and Africa, where soils are fragile (9). Most of this large reservoir of land is far from large population centers and their food demands. Consequently, cultivation is being extended into more accessible areas that are too dry, too cold, or too steep.

Though the world's best cropland is already under cultivation, most countries still have some uncultivated arable land (10). These countries are faced with either increasing the productivity of cropped land or of bringing more land under cultivation. Expanding the cultivated area frequently leads to degradation of the new land, while increasing crop yields generally improves the land and reverses the degradation process.

METHOD OF ANALYSIS

Rates of land degradation (desertification) were estimated and applied to land productivity measures to assess how anticipated degradation would affect future world food supplies. Desertification means the deterioration of the land's productive capacity through poor management. Six major regions of the world were analyzed on a global and regional basis.

This analysis assumes that existing economic relationships and government policies to control land degradation and increase land productivity will continue.

Background

Land degradation due to poor management has plagued the world for thousands of years. Land quality declined significantly around the Mediterranean Sea and in the loessial hills of China 1,000 years ago. Overgrazing, timber cutting, cultivation of sloping and sandy land, and irrigation without drainage led to accelerated water and wind erosion, increased water runoff and flooding, and salinization and waterlogging of irrigated lands.

Until recently, desertification went unrecognized in its early stages or was seen as a local problem. Land conservation had little appeal as long as farmers could avoid remedial action by moving on to new frontiers. It was not until easy land expansion ended in the 20th century, that the threat of continued natural resource degradation was finally realized.

The term desertification was coined in 1949 in a book on soil erosion that associated desertification with the humid and subhumid tropics in West Africa, where tree cutting, indiscriminate use of fire, and cultivation exposed the soil to water and wind erosion (1).

The United Nations Conference on desertification in 1977 focused its attention on desertification in arid lands. The causes of land degradation were traced to soil erosion, salinization and

waterlogging, soil compaction, soil crusting, loss of soil fertility, and a deterioration in range ground cover due to overgrazing and woodcutting. In this report, however, desertification includes all the conditions referred to in the U.N. conference on humid regions as well as on arid lands. The definition used is the following:

> Desertification is the impoverishment of terrestrial ecosystems under the impact of man. It is the process of deterioration in those ecosystems that can be measured by reduced productivity of desirable plants, undesirable alterations in the biomass and the diversity of the flora and fauna, accelerated soil deterioration, and increased hazards for human occupancy (4).

Nothing in this definition restricts desertification to the arid regions. However, the causes of reduction in the production potential of ecosystems may differ depending upon climatic zones. Accelerated water erosion is the major human-induced degradation problem in the humid regions. Overgrazing and wind erosion are likely to be critical in the drylands. Mining operations, on the other hand, are carried out in all climatic areas and cause about the same effect everywhere.

Worldwide rates of land desertification are impossible to determine with any degree of reliability because little field information is available. The Food and Agriculture Organization (FAO) of the United Nations has examined soil degradation since 1974. One of its objectives is a methodology for determining the present rate of soil degradation, a goal still several years off. For this report, an estimate of land degradation rates classified as low, moderate, and high is presented in appendix figure 13. Degradation rates may vary widely within countries; the distinctions made among countries are based on the averages of degradation for the agricultural land. The severe classification for Egypt applies only to the irrigated land and the Mediterranean coast, not to the virtually uninhabited deserts that constitute most of the nation.

Land Classification

The classification system used in preparing the continental desertification maps is based on four classes of desertification: slight, moderate, severe, and very severe (see app. figs. 1, 3, 5, 7, 9, and 11). The criteria for each class are shown as follows:

Desertification class	Plant cover	Erosion	Crop yields
Slight	Excellent to good range condition	None to slight	Crop yields reduced less than 10 percent
Moderate	Fair range condition	Moderate sheet erosion, shallow gullies, few hummocks	Crop yields reduced 10 to 50 percent
Severe	Poor range condition	Severe sheet erosion, gullies common, occasional blow-out area	Crop yields reduced 50 to 90 percent
Very severe	Land essentially denuded of vegetation	Severely gullied, or numerous blow-out areas	Crop yields reduced more than 90 percent

Desertification is a land degradation process, where land becomes progressively less productive. The result is very severely desertified land, which is so badly degraded that it is useless to humans or animals. That last stage is economically irreversible for most purposes. While many small land areas fit into this category, few are large enough to be shown on the small-scale continental maps in this study. Nearly all of the world's desertification currently can be reversed.

The amount of agricultural land in each of the four desertification classes for the six continents is shown in table 1. South America has the least land in the moderate, severe, and very severe categories and most in the slight desertification category. Its population lives mostly within 200 kilometers of the coast; the great majority of its slightly desertified land lies in the Amazon Basin and the Chaco region where the population is sparse and the environment inhospitable. Australia has the least land in the slight desertification category and most in the moderate desertification category because livestock numbers, principally sheep, have greatly exceeded the carrying capacity of low-productivity rangelands for decades, producing serious and lasting degradation of land.

Severe degradation of rangeland and cropland is most extensive in Africa north of the equator and in Southwest Asia. Large parts of China, the Soviet Union, Greece, Spain, the United States, Mexico, Central America, and the Andean countries of

Table 1--Desertification of land surfaces

Continent	Desertification class			
	Slight	Moderate	Severe	Very severe
	Percent			
Africa	60	23	17	0.1
Asia	56	28	16	--
Australia	38	55	7	--
Europe	69	25	6	--
North and Central America	70	23	7	.2
South America	73	17	10	.1
Six continents (avg.)	62	26	12	.1

-- = Less than 0.05 percent.

South America have also suffered much land degradation. Very severe desertification has occurred on all continents, but the great majority of the affected areas are too small to show on small-scale maps and are not, therefore, accounted for in table 1.

Land Productivity

A comprehensive study of land productivity has grouped the land area of the world into six land productivity classes and a large number of subclasses (3). The productivity values for each class are as follows:

Class	Land productivity grain equivalents 1/
	Kilograms
I (extremely high)	More than 25,000
II (very high)	20,000 to 25,000
III (high)	15,000 to 20,000
IV (medium)	10,000 to 15,000
V (low)	5,000 to 10,000
VI (very low)	Less than 5,000

1/ Maximum production of grain equivalent in kilograms per hectares per year.

Source: (3)

Land productivity maps for the six crop-producing continents use these six productivity classes (see app. figs. 2, 4, 6, 8, 10, and 12). Grain equivalents, the basis for the classification system, refer to the maximum potential production of plant dry matter (roots, stems, leaves, flowers, and fruits) converted into its equivalent in grain which can be achieved per unit area. Calculations included the annual growing period, the fraction of time the sky was overcast, the amount of water available for plant growth, and the mean sum of sunshine hours.

The area of all land in each of the six productivity classes, by continents, is shown in table 2, and the percentage of land in each class is shown in table 3. Class I land (about 1.4 percent of all land) is invariably found in the humid tropics where solar radiation is high, water is adequate for plant growth throughout the year, soil conditions are favorable, and the land is smooth and level. Some 27 percent of the land is in the first three categories, meaning that more than one-quarter is potentially highly productive. By current standards, the top five classes of land are all at least reasonably good land. Class VI, 47 percent of the total, includes poor land and land that is marginal because of climatic or soil limitations. Still, class VI land is important to the economies of many nations. For example, virtually all of the cultivated land in Niger and nearly one-third of cultivated land in Nigeria is class VI land.

South America has the greatest percentage, 62.8 percent, of potentially highly productive land. However, that figure is deceptive because most of that land, as well as land suffering

Table 2--Total land area in productivity classes, by continent

Class	Africa	Asia	Australia and New Zealand	Europe	North America and Central America	South America	Six continents
			Million hectares				
I	65	120	0	0	0	11	196
II	276	280	152	7	109	416	1,240
III	716	430	58	49	273	691	2,217
IV	236	763	57	389	137	271	1,853
V	214	103	145	392	827	0	1,681
VI	1,523	2,694	466	213	1,074	391	6,361
Total	3,030	4,390	878	1,050	2,420	1,780	13,548

Source: (3)

Table 3--Percentage of land area in various land productivity classes, by continent

Class	Africa	Asia	Australia and New Zealand	Europe	North America and Central America	South America	Six continents
				Percent			
I	2.1	2.7	0	0	0	0.6	1.4
II	9.1	6.4	17.3	.7	4.5	23.4	9.1
III	23.6	9.8	6.6	4.7	11.3	38.8	16.4
IV	7.8	17.4	6.5	37.0	5.7	15.2	13.7
V	7.1	2.3	16.4	37.3	34.2	0	12.4
VI	50.3	61.4	53.2	20.3	44.3	22.0	47.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: (3)

slight desertification, lies in or near the Amazon River basin where few people live. Farmers have chosen to concentrate their settlements on the periphery of the basin. The reluctance to settle within the basin may be due to health considerations, difficulties in clearing land, transportation and communication problems, or personal prejudices, as well as the inability to cope with the fragile soil due to erosion and drainage problems.

EFFECTS OF DESERTIFICATION ON FOOD PRODUCTION

Analysts have evaluated the inherent productivity of soils in specific soil groups or soil orders and related that to total crop productivity. The most comprehensive analysis of land productivity, the Agro-Ecological Zones Project, is being conducted by the FAO (6). The project's purpose is to determine the crop production potential of the world's land resources, including the climatic and soil requirements of several crops and specific levels of inputs and technology. Soil data come from the Soil Map of the World Project that has recently been completed. Only rainfed crop production is estimated, thus far. Again, land degradation is not an explicit component of the evaluation process.

Desertification will affect food production by the year 2000. Any climate change that may occur by the end of the current century is assumed to have no significant effect on food production, according to the survey conducted by the U.S. National Defense University, which concluded that the most likely climate by the year 2000 would resemble the average for the past 30 years (8).

Africa

Desertification in Africa is worst on the north and south sides of the Sahara (app. fig. 1). Water erosion is the primary problem in the Maghreb countries of Algeria, Morocco, and Tunisia; in the semiarid regions of eastern and southern Africa; and in the subhumid sections of the continent. Wind erosion has decreased soil fertility significantly in the Sahel countries from Mauritania to the Sudan. Overgrazing has plagued all the rangelands outside the tsetse-affected areas. Salinization and waterlogging, as human-generated problems, have most extensively affected the Nile River Valley and Delta. Food production will likely increase slowly throughout the continent, spurred by improved management practices. South Africa and Botswana are expected to increase crop yields faster than other African countries. Lesotho, Ethiopia, and the semiarid, subhumid regions between the Gulf of Guinea and the Sahara will probably suffer declining per capita food production.

Soil Conditions

The precarious food situation on most of the continent and the degree of land degradation indicate a continuing problem.

North Africa--Deforestation, excessive grazing, and the extension of cultivation to sloping and shallow soils and into dry zones are responsible for severe land degradation in the semiarid and subhumid regions of Morocco, Algeria, and Tunisia. Locally severe salinization and waterlogging aggravate problems in some of the irrigated lands. While conspicuous gully erosion has been slowed considerably, sheet erosion by water and wind continue to reduce soil productivity. Overgrazing and excessive woodcutting have not been controlled. Soil conservation programs have had uneven success. The expansion of cultivation now underway is on marginal lands that were previously used for grazing and are, at best, hazardous for cropping.

Wind erosion is more serious in Libya than in the other North African countries because more of the cultivated land has sandy soils. Accelerated water erosion is confined to coastal areas and is generally not severe. Salinization and waterlogging are minor, but overgrazing is widespread.

Sahel--In the Sahelian region stretching from Senegal in the west to Ethiopia in the east, wind erosion is the dominant degradation process west of Chad, because of overgrazing, drought, and dryland farming of sandy lands. Soil fertility loss, which accounts for much of the poor yields of millet and sorghum, is the result of a combination of wind erosion, failure to apply plant nutrients in the form of commercial fertilizers or manures, and greatly shortened fallow periods. Wind erosion is rampant on the rangelands where plant cover is sparse because of overgrazing and woodcutting. Water erosion affects the sandy uplands as well as the hills and slopes.

In the eastern Sahel, wind erosion is damaging cultivated soils in the drier regions, especially in the Sudan. Elsewhere, water erosion is a greater problem, especially in Ethiopia, where the situation has become much worse in recent years, particularly in the cultivated highlands. Somalia is experiencing serious water erosion in the dryland farming areas of the north.

East Africa--Moderate-to-severe overgrazing outside the tsetse fly region plagues East Africa. Water erosion is severe in the semiarid cultivated lands of eastern Kenya and northern Tanzania. Land degradation will intensify in the tsetse areas of Tanzania and other countries when effective fly control measures are instituted and livestock grazing increases.

Southern and West Africa--Southern Africa shows all degrees of desertification, from slight in the arid Kalahari Desert to very severe in Lesotho. Overgrazing mostly occurs around watering points in Botswana, but most of the rangelands are in reasonably good condition. Water erosion of cultivated lands in Lesotho, eastern South Africa, and Swaziland is a longstanding problem that has been partly corrected in South Africa. Lesotho, together with Nepal in Asia, probably are experiencing the worst land degradation of any country in the world.

The most humid parts of Africa show little evidence of desertification. Destructive water erosion is concentrated in the subhumid regions where permanent cultivation is widespread and population pressures are increasing. Land degradation can get worse in the future, but it is unlikely that it will assume major proportions by the year 2000 in West Africa from Cameroon to Angola and in the humid zone along the Gulf of Guinea.

Egypt--Lower Egypt and the New Valley oases have been threatened by salinization and waterlogging for decades. Since completion of the High Aswan Dam, however, those problems have become worse in the Nile Delta and Valley as perennial irrigation has led to rising ground-water tables and the absence of the formerly annual flushing of salts. The problem has been recognized and remedial measures initiated. However, drainage is costly to implement, requiring many years before it is extended to all the lands that need it. Meanwhile, farmers are improving onfarm water management and reducing water loss.

The salinity problem persists in the oases of the New Valley. Desert dunes are encroaching upon some of the land in the oases and in the Nile Valley.

Salinization and waterlogging have also affected the new irrigation developments on the uplands west of the Nile Delta. Porous surface soils and saline substrata have contributed to rising

water tables and salinization, reducing crop production. Irrigation practices suitable in the Nile Valley are unsuitable for much of the upland soils. Wind erosion of the coarse-textured soils has also damaged the land, filled irrigation canals, and hampered water distribution.

Land Production Potential

Potential land productivity in Africa is greatest in the humid tropics and in the lower Nile Valley (app. fig. 2) (4). The large areas of Class I land are in northern Egypt, Zaire, and the Congo Republic. Productivity losses due to desertification of cultivated land are likely in Lesotho and Ethiopia, where severe water erosion continues. Conditions should improve in South Africa, and degradation should be slowed considerably in the countries bordering the Mediterranean Sea, where governments are taking steps to conserve and improve soil resources.

Rainfed cultivated lands will expand in the semiarid and subhumid zones along the southern tier of the Sahara as the population increases. Cultivation will move north in wet years into climatically more hazardous areas, and land degradation will accompany that move. A considerable amount of moderately productive uncultivated land is still available for cropping in much of the region. Agricultural expansion and the associated land degradation are not likely to hurt crop yields on rainfed lands, but meat production will probably decline. A modest improvement in the use of fertilizers, combined with better crop varieties and improved management practices, probably will be offset by the low fertility of the sandy soils and climatic difficulties.

Total crop production under irrigation in Egypt should increase as new land is farmed. Yields on new lands will be limited, however, and yields in established areas can be expected to increase only slowly.

Food production in the largely undesertified humid tropics could be greatly increased if current research is successful. The best farming system in such areas when agricultural production is intensified remains to be determined. Porous soils, heavy rains, a year-round growing season, and high insolation during dry periods are unresolved problems.

Overgrazing and woodcutting will cause a slight increase in desertification in the rangelands of Africa north of the Equator, but they are unlikely to hamper livestock production. Present conditions of low to very low productivity will likely continue indefinitely except, perhaps, in Kenya, which is developing a good range management program that could improve conditions within 10 to 20 years. The greatest threat to meat production, aside from droughts, diseases, and pests, is the continued encroachment of cultivation onto the better rangelands; that trend is expected to continue.

Southern Africa, except for Lesotho, will likely arrest most rangeland deterioration by the year 2000. Cropland deterioration in South Africa is fairly well under control, but remains a serious problem in Lesotho, Swaziland, and Madagascar. The other countries of southern Africa are not seriously affected by land degradation over large areas.

Asia

Desertification in Southwest Asia is a longstanding problem that has worsened, particularly on rangelands, over the last few decades. In Southeast Asia, land degradation is a matter of relatively recent concern. Central, northern, and western areas of China have had serious erosion problems for many decades, as have India and Pakistan. Grazing and cultivated lands of the Soviet Union's central Asia region have suffered from erosion and salinization of irrigated land for more than a century, but little degradation has occurred in the vast and sparsely settled northern third of the continent. Mountainous Nepal is now suffering some of the worst erosion in the world (app. fig. 3). Land degradation, mostly from water erosion on cultivated land, will strike most severely in Nepal and Indonesia showing its full effects in the next century. Overall Asian crop yields should increase slowly until the year 2000 based on farming improvements in the Philippines, North and South Korea, Taiwan, Japan, the Soviet Union, Israel, and, perhaps, Turkey.

Soil Conditions

The continent's expanding population and soil problems threaten Asia's ability to feed its people.

Southwest Asia--The region's most severely deteriorated lands span an area from Afghanistan to Turkey. Desertification continues to reduce crop production. Iran partially controls wind erosion of sandy soils; however, marginal land is being increasingly cultivated, spreading land degradation. Crop yields can be sustained or increased only by the use of commercial fertilizers and other technological advances. Rangelands continue to deteriorate as they shrink.

Salinization and waterlogging is largely confined to Iraq, and to a lesser degree, eastern Syria. Newly irrigated areas in Syria have salinity problems that will likely reduce crop yields.

Much of Southwest Asia is overgrazed. The situation has stabilized in recent years at a low level of productivity, which will likely continue to the end of the century.

South Asia--Bangladesh has little or no desertification, but Nepal suffers severely from water erosion in the upland regions of the Siwalik Hills and the Himalayas. Pakistani growers are plagued by severe water erosion in dryland farming areas,

deforestation of northern watersheds, overgrazing of rangelands, wind erosion, and salinization and waterlogging of Indus Basin irrigated lands. Major soil conservation and range management programs have succeeded only in improving the salinization and waterlogging problems.

India shares similar problems with Pakistan, although improvement of India's research and extension efforts has arrested some land deterioration and has established effective soil and water conservation programs. Increased crop production prospects appear good in India and Sri Lanka, even without a major expansion in irrigation.

Nepal's rate of water erosion has accelerated during the past few decades and shows no signs of slowing. Part of the pressure on land resources has been relieved by migration to the humid and low-lying Terai region in southern Nepal, an outlet that will probably be closed to settlers from Nepal and India by the year 2000 because of overpopulation. Land productivity will continue to decline as forests are cut down and cultivation expands to marginally favorable sites. Crop production in Nepal's highlands is virtually certain to decline in the years ahead.

Southeast Asia--Land degradation was not a widespread problem in Southeast Asia until a few decades ago. The early stages of degradation reach into the highlands of Thailand, and desertification from water erosion burdens farmers on the densely populated Indonesian island of Java. Thailand will face serious desertification problems as more of the forested highlands are cultivated. Water erosion, following extensive deforestation, has hampered crop production in parts of northern Vietnam, but the remainder of the country, as well as Burma, Laos, Cambodia, Malaysia, and the Asian islands, displays little evidence of degradation. Clear-cutting of timber on steep slopes has led to locally severe water erosion in Papua-New Guinea and other islands, a situation certain to get worse as commercial timber production expands in the region.

East Asia--Several kinds of land degradation have affected China's agricultural lands for centuries. In recent years, however, desertification has been reversed on much of the land, although water erosion persists in the loessial plateau of north-central China, and wind erosion still plagues some areas of western China. By the year 2000, desertification should be greatly reduced throughout China and South Korea, largely because of massive reforestation projects.

Crop production is not hampered by desertification in Japan, Taiwan, North Korea, and the Philippines.

Soviet Union--Most land degradation is under control in the Soviet Union, and conditions should improve by the end of the century. Wind erosion persists in the dryland farming regions of northern Kazakhstan, and salinization and waterlogging hamper growers along the great Kara Kum canal in Turkmenistan, but that problem should become less serious over the next 10 to 20 years. The formerly severe overgrazing and sand dune problems throughout Central Asia have been reduced in recent years.

Land Production Potential

Potentially highly productive land (Classes I, II, and III) in Asia is limited to the southern and southeastern parts of the continent (fig. 4). The largest area of Class I land is in the Ganges River plain of India and Bangladesh. Desertification threatens productivity potential, at present, only on the island of Java. Lands of medium to very low potential productivity are being degraded further in Thailand, Iran, and, especially, Nepal.

Australia and New Zealand

Australia continues to suffer from many years of overgrazing and erosion that occurred in the late 1800's and early 1900's. Practically all of the rangeland is moderately to severely desertified. Only the unpalatable spinifex grasses prevented excessive grazing in northwestern Australia. Salinization and waterlogging are perennial problems on the irrigated lands in the Murray River basin of southeastern Australia, and the situation is getting worse (app. fig. 5). Recent concern about the future of the irrigated lands may lead to remedial measures to resolve these problems, as well as the problem of dryland saline seepage in the southeastern and southwestern regions of the continent, by the end of the century.

Desertification is minor in New Zealand since the mostly pastoral economy in this humid region has protected the land against erosion. However, the South Island mining and timbering operations have caused some watershed problems.

Potential land productivity is highest in eastern and southeastern Australia and on the North Island of New Zealand (app. fig. 6). Actual productivity of the cultivated lands is expected to increase steadily in the years ahead. A moderate increase in meat production should occur in New Zealand. Meat production should stabilize in Australia's arid rangelands, although there should be significant increases in subhumid Queensland and in New South Wales.

Europe

Severe desertification problems in Europe are confined mainly to the countries bordering the Mediterranean Sea, principally Spain, Italy, and Greece, where most of the damage was done many centuries ago (app. fig. 7). Water erosion has been particularly severe in the semiarid and subhumid hilly regions. Erosion continues, but productivity is so low in the most severely affected areas that further degradation has little effect.

Salinization and waterlogging hamper crop yields in Spain's irrigated lands, especially in the Ebro and Guadalquivir watersheds, but conservation steps are limiting the damage.

The water erosion that scarred much of central Europe after tree removal on sloping land centuries ago has been largely controlled. Wind erosion in the European part of the Soviet Union has been arrested by the extensive protective tree planting program carried out in the Ukraine. Erosion continues on cultivated sloping lands, although the problem is only acute in certain limited areas in the south.

Land productivity potential in Europe generally is medium to low due to a combination of climatic and soil limitations (app. fig. 8). The most productive land is in the broad valleys and flood plains along the Mediterranean coast from France to Greece. Improved small farm technology has improved crop yields in recent decades in central and western Europe. Continued steady increases are expected.

North and Central America

Desertification in North America is mostly an arid-land problem, affecting Texas, New Mexico, and Arizona in the United States and the Mexican states from Oaxaca in the south to Sonora and Chihuahua in the north (app. fig. 9). Water erosion has severely damaged much land in the mountains of Guatemala, El Salvador, Honduras, and Nicaragua.

Deterioration of soils continues in Central America, but has slowed in Canada, Mexico, and the United States. Desertification will blunt upland food production in the mountainous Central American countries for the foreseeable future, while crop production on large lowland farms will increase.

Mexico's extensive overgrazing and woodcutting persist, and very serious water erosion plagues cultivated fields throughout the central highlands. Salinization and waterlogging hamper growers in much of the northern and eastern irrigated areas, especially in the Mexicali Valley. The Federal Government recognizes the desertification problem and has taken steps to arrest it, but progress is slow on small landholdings. The humid tropics have escaped most of the land degradation problems that affect the remainder of the country.

Canada has reduced its desertification problems, which mostly consisted of wind erosion and salinization in dryland farming areas in the prairie provinces. Land deterioration has been nearly halted except where affected by saline seeps. Those lands constitute about 1.5 million hectares (3.7 million acres), a small percentage of the Canadian wheatlands. The humid regions have no large-scale desertification problems.

The U.S. situation is variable. The worst degradation of lands occurred several decades ago from overgrazing, woodcutting, careless managing of humid region soils, expanding dryland farming into climatically marginal areas of poor soils, and irrigating unsuitable soils.

Deterioration of U.S. rangelands has nearly stopped on both private and public lands, but improving them will be a slow process. Water erosion in the semiarid and humid regions has been partially controlled; gully erosion is declining, but sheet erosion continues at unacceptable levels in many States. Wind erosion in the dry regions, particularly the southern Great Plains, has not been satisfactorily controlled on sandy soils. Salinization is a troublesome soil problem in the southwestern irrigated area; waterlogging is largely under control. Salinization will have an increasing, but probably small, effect on crop production in California's Imperial Valley. Salinity problems on irrigated land will likely decline if irrigation is terminated on some of the poorest lands.

The high quality of lands in lowland Central America and the U.S. gulf coast and Eastern United States is of little consequence in calculations of increased food production in the year 2000 (app. fig. 10). Virtually all of the best arable land in those zones is already being cultivated. Bringing new land under cultivation will be neither easy nor cheap. Desertification has scarred lands of medium to very low productivity, rather than harming the better farmland.

South America

Land degradation in South America has been most severe on the cultivated lands of the Andes Mountains and on the grazing lands of Argentina (app. fig. 11). Water erosion has been the main problem in the highlands, and wind erosion has caused much land damage in the Argentine lowlands on both range and cultivated areas.

A degree of stability has been achieved on much of the cropland and grazing lands of South America. Erosion continues but only slightly diminishes an already low productivity. The principal exception is the sandy dry farmlands of central Argentina, where attempts to control wind erosion have not been generally successful.

Salinization and waterlogging have reduced productivity of irrigated land in the valleys crossing the coastal desert of Peru and in the Sao Francisco Valley of Brazil. Adequate soil drainage should remedy those problems so that national food production is not further reduced by salinization or waterlogging.

Development of the humid Amazon Basin in Brazil, Peru, and Bolivia will determine how much worse soil degradation will be by the end of the century. Potential land productivity is higher there than in most of the continent (app. fig. 12). Analysts are uncertain whether stripping the land of trees to permit cultivation and livestock raising will severely reduce soil fertility. Excessive leaching of nutrients must be reduced, but little technology exists on farming systems in the humid tropics. The large-scale mechanized farming methods used in temperate regions must be modified before they can be used in the humid tropics. Some degradation of Amazon Basin soils is certain to occur during cultivation, since little research and education in the area exists, preventing the region from reaching its agricultural potential before the next century.

South America has the greatest amount of land (62.8 percent) in the top three productivity classes in the world. Much of that land lies in the Amazon Basin where current management techniques are unsuitable for large-scale mechanization of cultivated crop production on porous upland soils. Maintaining fertility is the major challenge on all of the highly leached soils of the tropics cleared for cultivation, both in or out of the Amazon Basin. The easiest soils to manage in South America are those in temperate zones and in the valleys along the Pacific slope. Land improvement is likely in all countries, but per capita food production growth will probably be slow.

Argentina has the greatest amount of uncultivated land which could be successfully farmed using current techniques. However, Colombia may show the largest crop yield increase per unit area. The land degradation that affects subhumid northeastern Brazil probably will not be reversed in the next 20 years because of the frequent and severe droughts typical of the region. Crop yields in the remainder of Brazil (outside the Amazon Basin) should continue to rise steadily.

Land degradation in the Amazon Basin is virtually certain to follow mechanized cropping there. Desertification on the remainder of the continent will probably continue slowly. Most of the land degradation damage in the croplands and rangelands has already been done. There is not likely to be any major reversal of desertification on the continent by the year 2000.

THE GLOBAL VIEW

Land degradation's effect on food production can vary within a single country. The serious erosion occurring on Java, for example, has only a modest effect on national food production, and per capita food production probably will continue to increase until the year 2000.

In most countries, per capita food production is expected to increase from 1980 to 2000, despite the land degradation that has occurred or will probably occur (app. fig. 14).

Land degradation will most seriously hamper food production in a large group of countries extending from the west coast of Africa to the Sea of Japan, in Mexico, five Central America republics, and Haiti.

Numerous factors besides desertification will affect the level of food production in the year 2000. Most important is the commitment of a government to increase production; without that, progress will be slow or nonexistent in the developing countries of the world. Other factors, all influenced by government policies and the availability of funds, include the effectiveness of research in developing improved plant varieties, better land and water management systems, and the ability of the education and extension systems to assist in the adoption of improved practices. Also, the availability of credit; timeliness of fertilizer, seed, and pesticide distribution; storage facilities; and the adequacy of transportation and communication facilities will determine the success of the food production system. Climatic changes and increases in costs of imported materials are, of course, the two uncontrollable elements.

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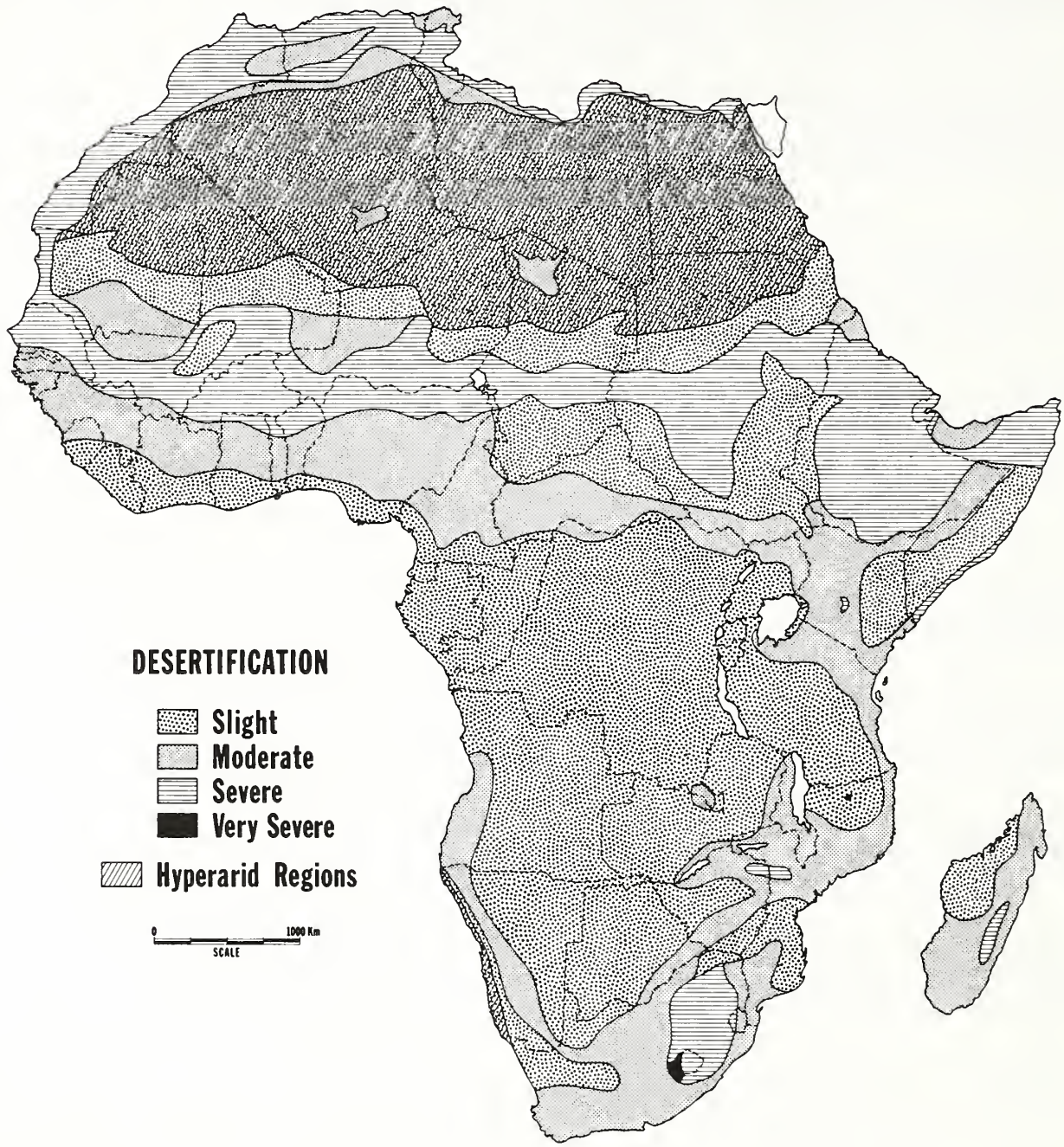
APPENDIX

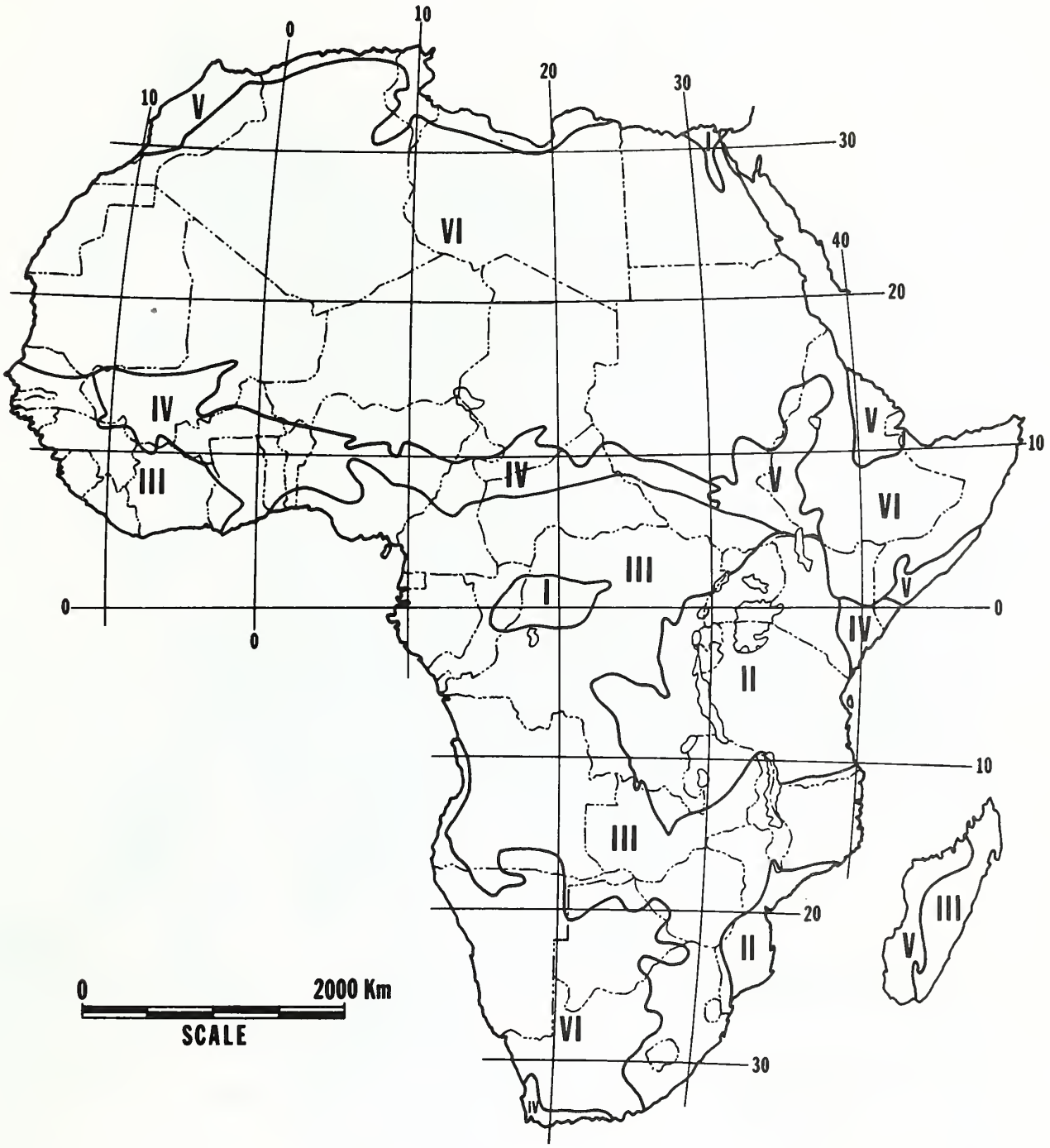
Delineations on the appendix maps, because of the small scale employed, nearly always are combinations of different desertification classes. For example, an area shown as moderately desertified usually will include slightly desertified and severely desertified land.

Map classification	Percentage of area in various desertification classes
Slight desertification	more than 50% in slight category less than 20% in severe category less than 10% in very severe category
Moderate desertification	less than 50% in slight category less than 30% in severe and very severe category
Severe desertification	more than 30% in severe category less than 30% in very severe category
Very severe desertification	more than 30% in very severe category

Appendix figure 1--Africa: current status of land desertification

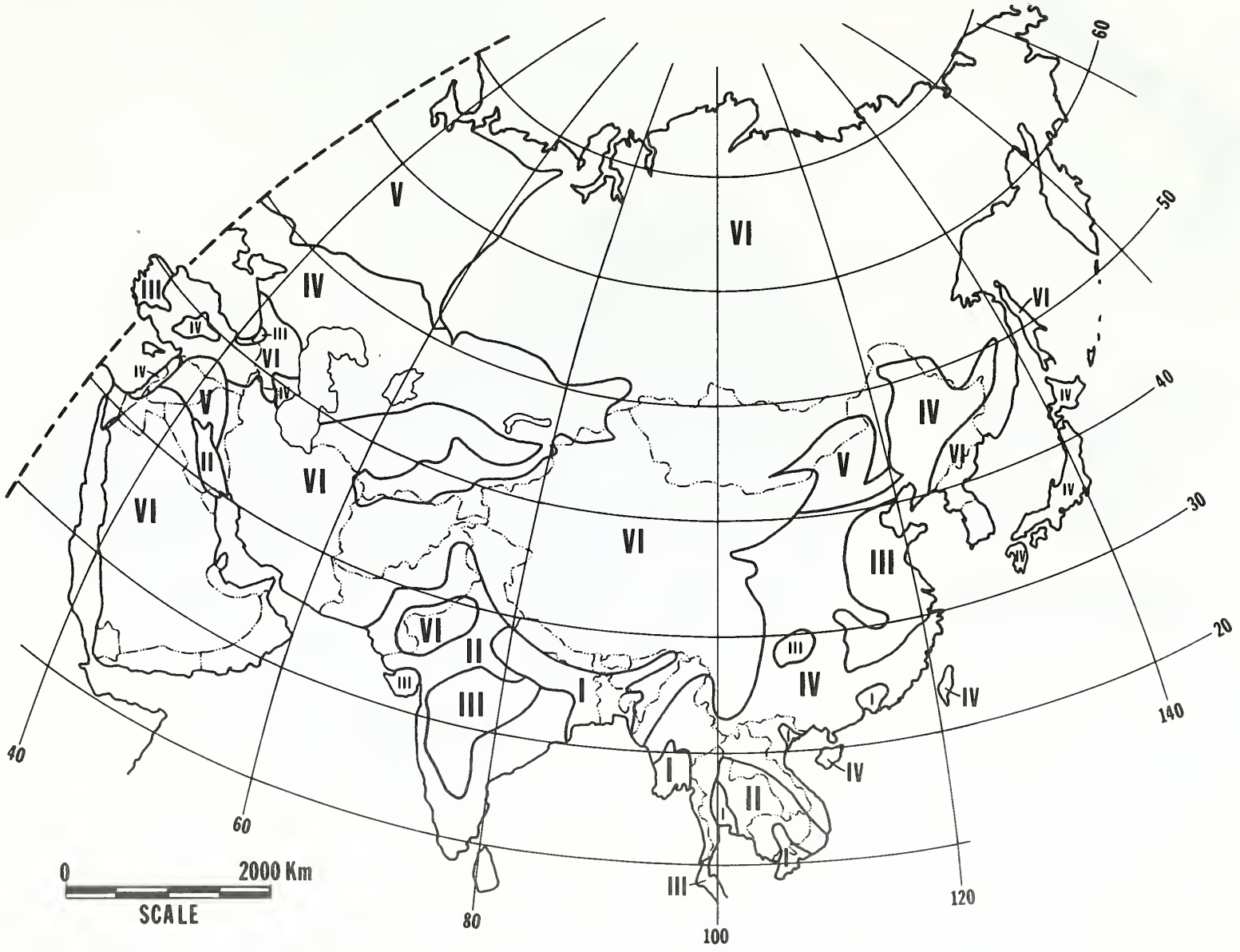


Appendix figure 2--Africa: land productivity classes



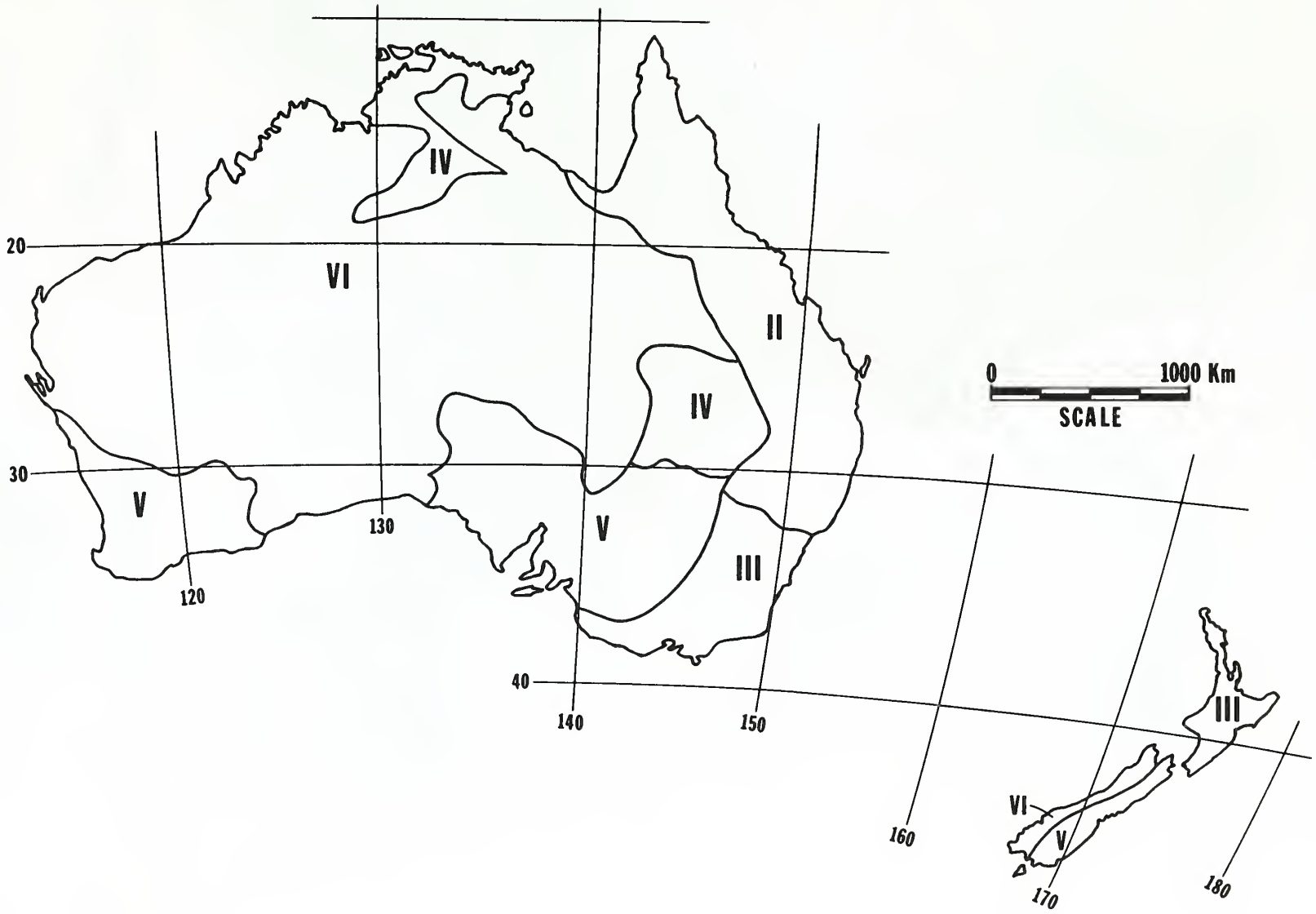
Appendix figure 3--Asia: current status of land desertification

Appendix figure 4--Asia: land productivity classes



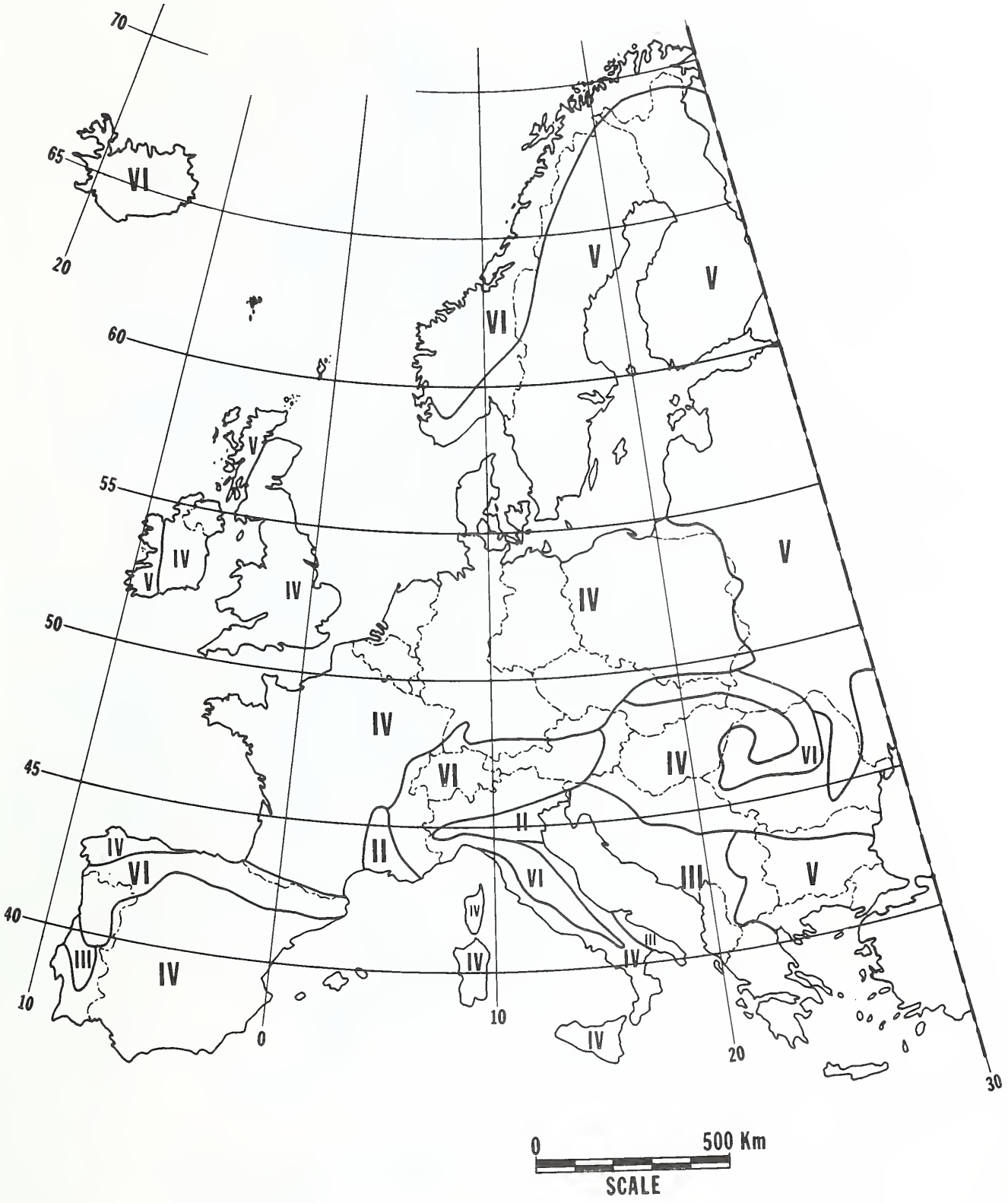
Appendix figure 5--Australia and New Zealand: current status of land desertification

Appendix figure 6--Australia and New Zealand: land productivity classes



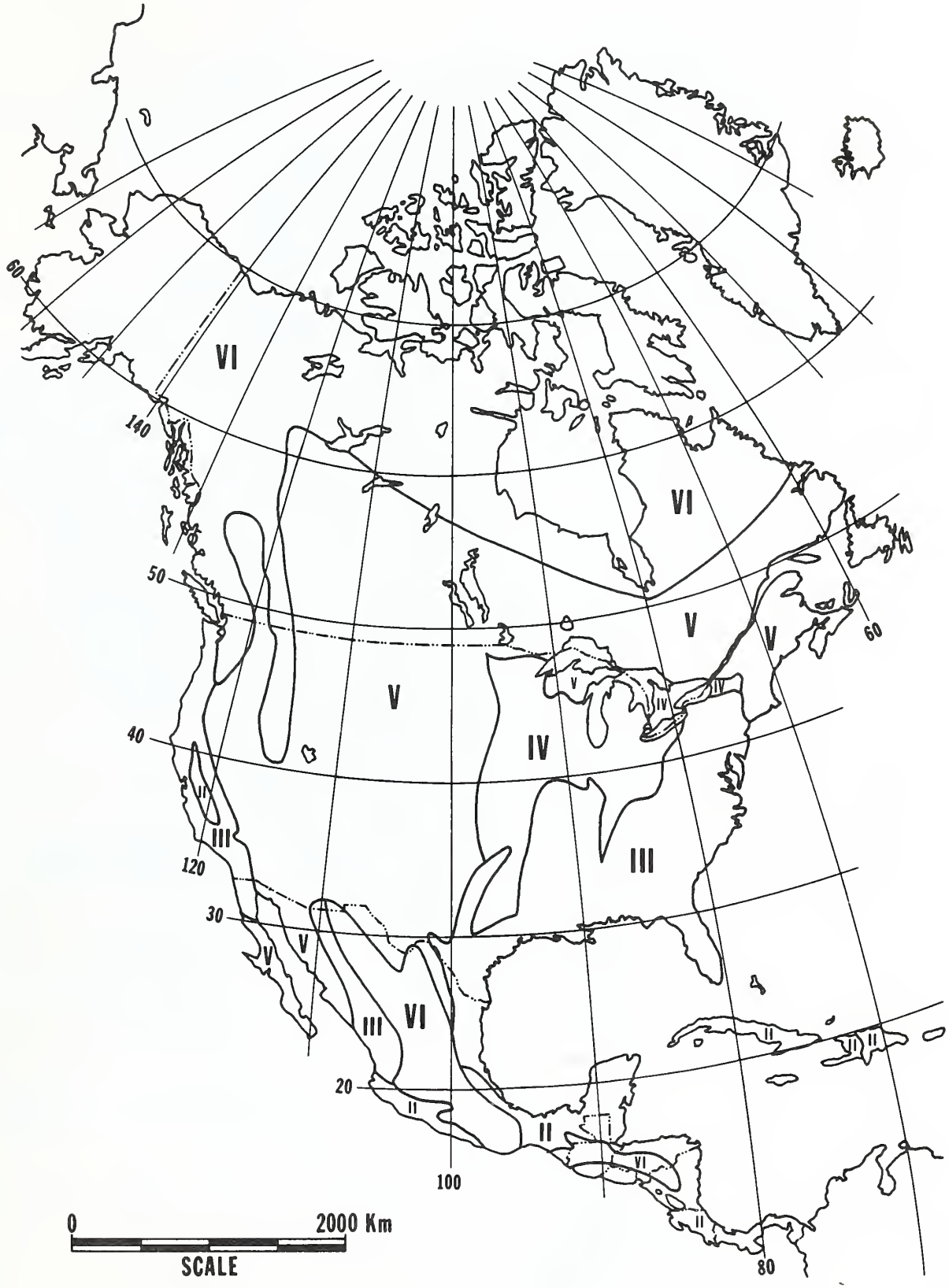
Appendix figure 7--Europe: current status of land desertification

Appendix figure 8--Europe: land productivity classes

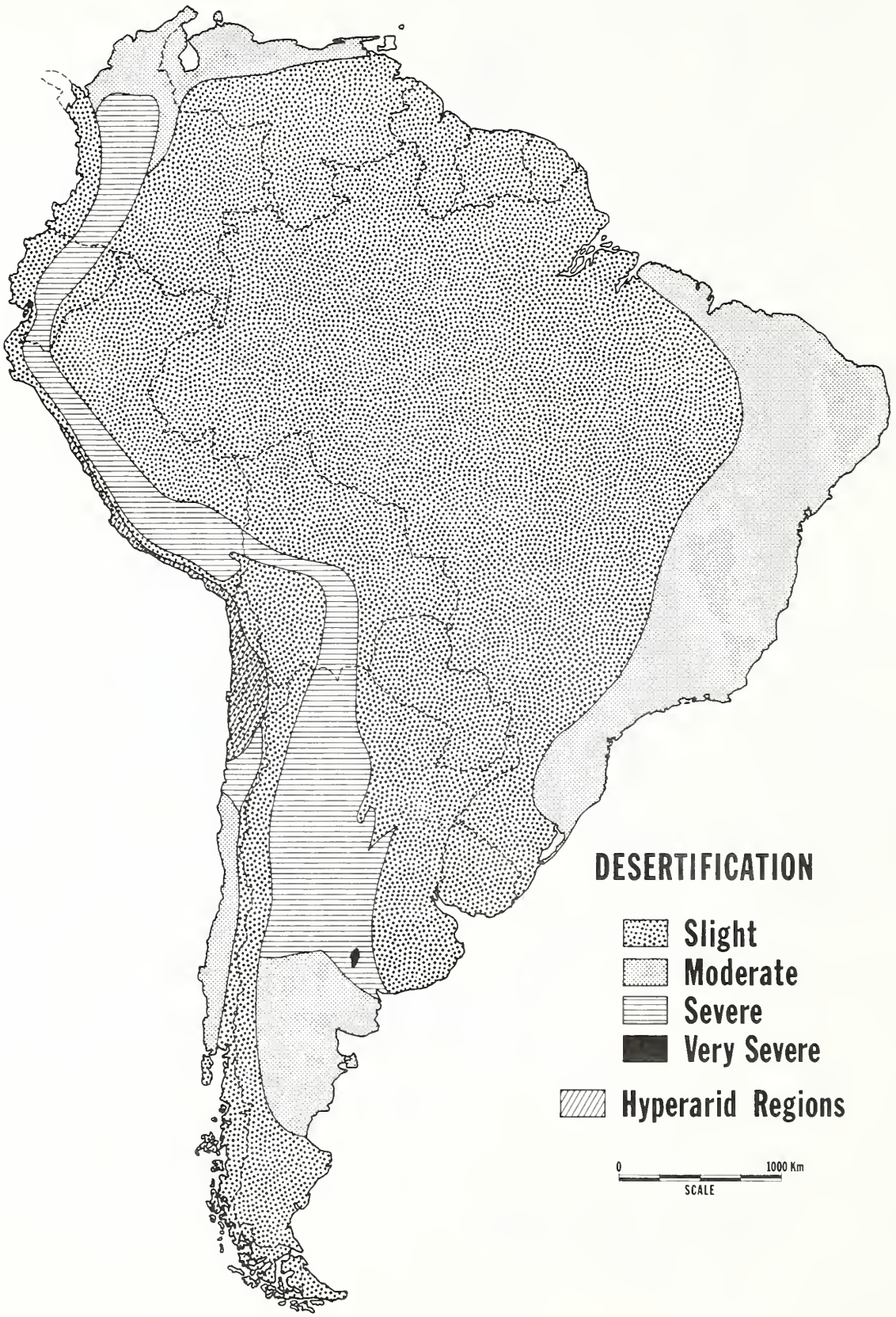


Appendix figure 9--North America and Central America: current status of land desertification

Appendix figure 10--North America and Central America: land productivity classes

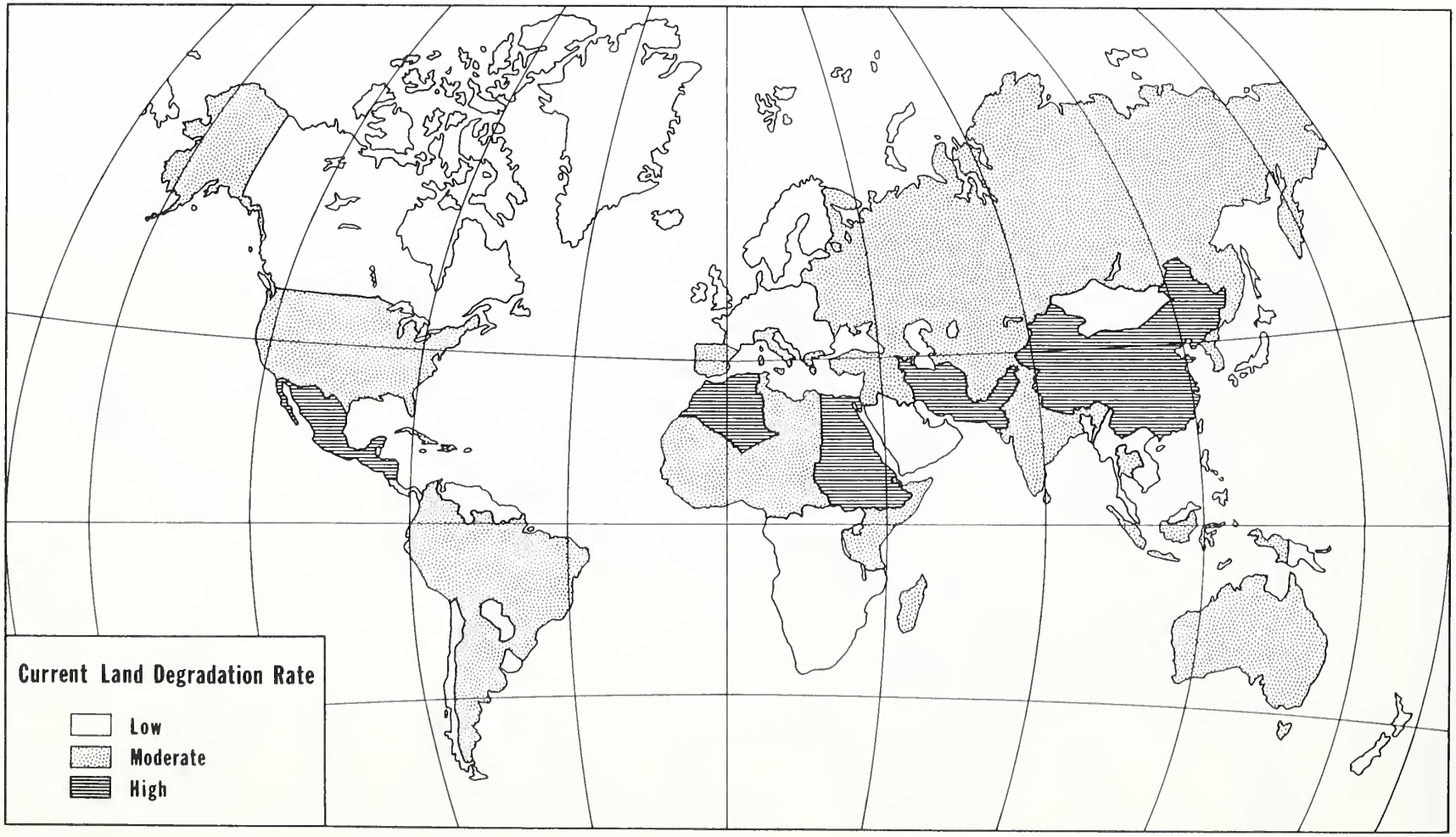


Appendix figure 11--South America: current status of land desertification

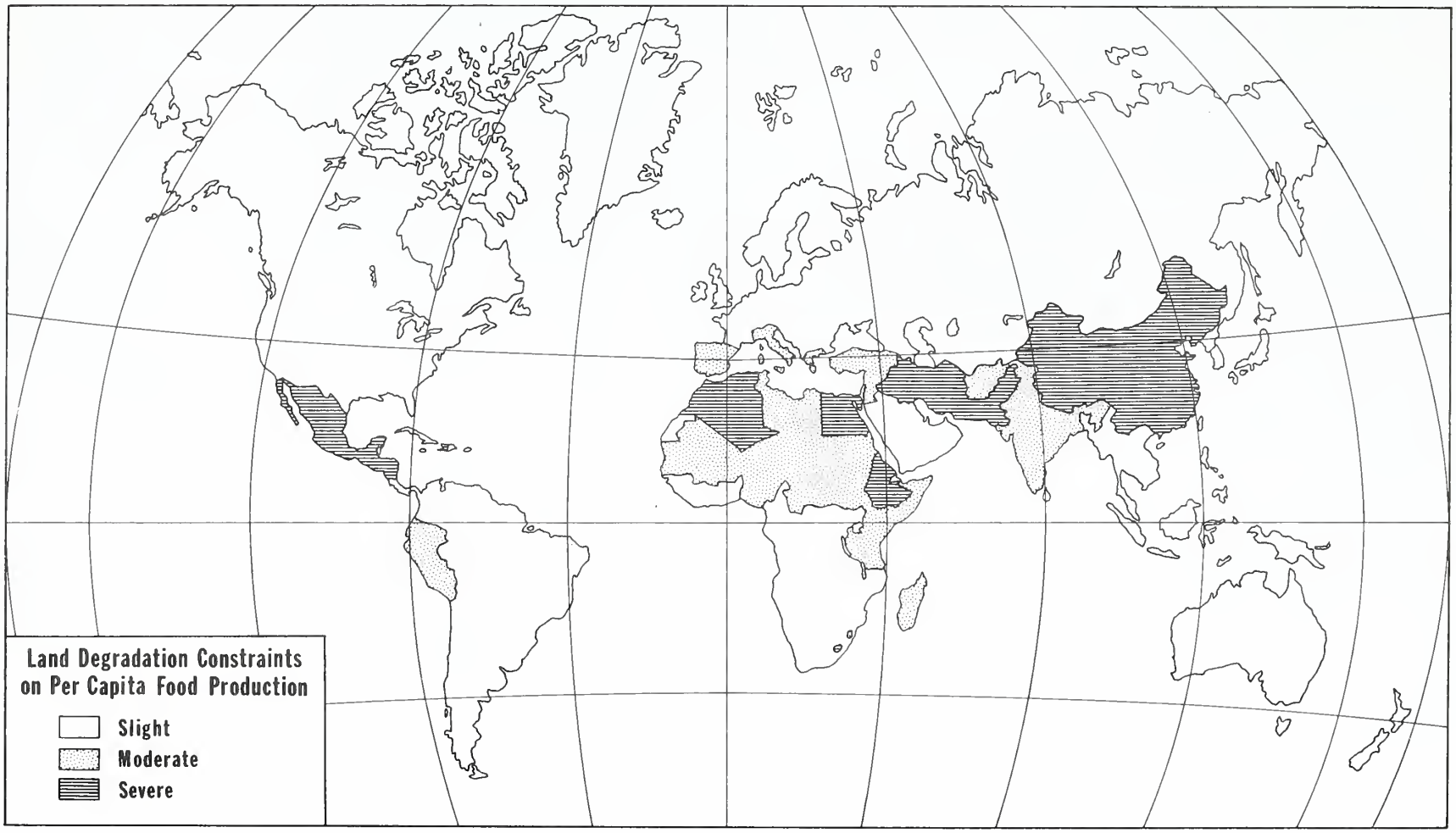


Appendix figure 12--South America: land productivity classes

Appendix figure 13--Current agricultural land degradation rate, by continent



Appendix figure 14--Severity of current land degradation constraints on per capita food production, by continent



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